Research of New Generation 3D Printer

K.R. Hajiyeva
Sumgait State University (43rd block, Sumgait, AZ5008, Azerbaijan)

For correspondence:
Hajiyeva Konul / e-mail: konul.haciyeva.1974@mail.ru

Abstract

In the article, a new generation 3D printer is designed to improve the technological performance based on the analysis of 3Dprinter design principles, and it is proposed to prepare a software-controlled stabilization system, by studying the features of the optimal stabilization system for hastiness. The issues of research and synthesis of the control system of the working body of the 3D printer were considered, and at the same time the optimal control algorithm was developed.

Keywords: 3D printer, plastic thread melter, optimal control, haste.

DOI: 10.52171/2076-0515_2021_13_04_107_112

For citation:
Hajyeva K.R.
[Research of new generation 3D printer]
Herald of the Azerbaijan Engineering Academy; 2021, vol. 13, no. 4, pp. 107-112 *(in English)*

Yeni nəsil 3D-printerin optimal sintezi

K.R. Hacıyeva
Sumqayıt Dövlət Universiteti (43-cü məhəllə, Sumqayıt, AZ5008, Azərbaycan)

Yazışma üçün:
Hacıyeva Könül / e-mail: könül.haciyeva.1974@mail.ru

Xülasə

Məqalədə 3D-printerlərin layihələndirilməsi prinsiplərinin analizi əsasında texnoloji göstəricilərinin yaxşılaşdırılması üçün yeni nəsil 3D-printeri konstruksiya edilmiş və cəldişləməyə görə optimal stabilləşdirmə sisteminin xüsusiyyətləri araşdırılmaqla proqram idarəli stabilizasiya sisteminin qurulması təklif olunmuşdur. 3D-printerin idarəetmə sistemləri həm layihələndirmə, həm də istismar mərhələlərində mahiyyət etibarı ilə ikisəviyyəli sistem kimi baxılmışdır. 3D-printerin işçi orqanının mühərriklərinin idarəetmə sisteminin tədqiqi və sintezi məsələlərinə baxılmış, eyni zamanda optimal idarəetmə məsələsinin qoyuluşu və printerin idarəetmə alqoritmi işlənmişdir.

Açar sözlər: 3D-printer, plastik sap əridicisi, optimal idarəetmə, cəldişləmə.

DOI: 10.52171/2076-0515_2021_13_04_107_112

УДК 621.9

Оптимальный синтез 3D-принтера нового поколения

К.Р. Гаджиева
Сумгаитский государственный университет (43 квартал, Сумгаит, AZ5008, Азербайджан)

Для переписки:
Гаджиева Кенюль / e-mail: konul.haciyeva.1974@mail.ru

Аннотация

В статье разработан 3D-принтер нового поколения для повышения технологических показателей на основе анализа принципов проектирования 3D-принтера, а также предлагается подготовить программно-управляемую систему стабилизации, изучив особенности оптимальной системы. Системы управления 3D-принтером, считаются по существу двухуровневой системой как на этапе проектирования, так и на этапе эксплуатации. Рассмотрены вопросы исследования и синтеза системы управления исполнительными механизмами и рабочим органом 3D-принтера, а также разработана задача оптимального управления и алгоритм декомпозиционного управления принтером.

Ключевые слова: 3D-принтер, растворитель пластиковых нитей, оптимальное управление, закаливание.

Herald of the Azerbaijan Engineering Academy
2021, vol. 13, no. 4, pp. 107-112
Hajiyeva K.R.

Introduction

Currently, layered assembly-additive technologies are widely used [1, 2] in the three-dimensional synthesis of devices, and one of the fastest-studied technologies belonging to this class are 3D-printers. Recently, 3D-printers created by engineers allow to print a large number of products from different materials.

The conducted analysis shows that the existing 3D-printers don't have high maintenance parameters, so the accuracy of the movement of its thread head through the vertical and horizontal guides, using slot connectors is due to wear of the working and guide elements, identificating of errors and inaccuracies that occur, due to which the wear cycle of the device requires monitoring of its movement in the *X*, *Y* and *Z* [1,2,3] axes. If there is deflection, the table will be inclined to an uncertain position (both in volume and direction) that may change during the formation of the product, not in a horizontal position. In other words, the presence of deflection causes the table stand to vibrate during the formation of the product. Thus, even a small inclination in space while the thread head moves along the *X* axis would cause the distance between the thread surface of support and the table to change monotonously during printing, regardless of whether the support is positioned along the *Y* and *Z* axes. In addition, the degree of this change affects how much the shape of the thread element is bent, and the appearance of the printed element produced as a result of the above adverse effects, leads to a loss of production accuracy [1, 2, 3].

However, in order to turn a new 3D-printer into a mass product, manufacturers are focusing must on solving technical and theoretical problems. Among them, along with the mentioned shortcomings, is the planning of the technological trajectory of the plastic thread melter-tip of the 3D-printer and the improvement of the tracking system.

The purpose of the work

The creation and management of a new generation 3D-printers based on the analysis of the principles and parameters of the installation of 3D-printers.

The setting of the issue

In this regard, we have proposed a new generation 3D-printer [3] (Figure 1). Fig. 1 shows the mechanical design scheme of the 3D design model of the 3D-printer.

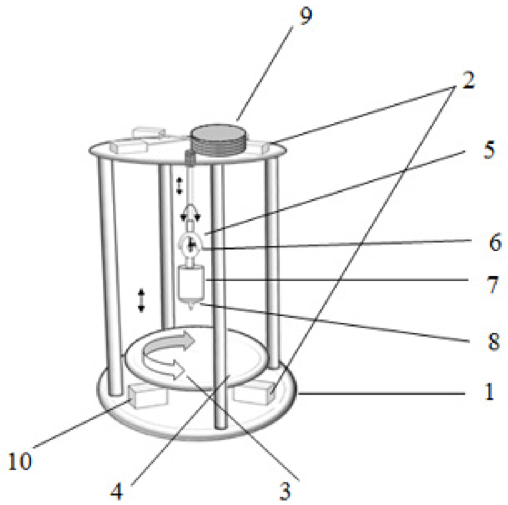

Figure 1 – Mechanical design scheme of 3D-printer model

As seen from Fig. 1 3D-printer consists of 1 - general support, 2 - the fastening elements of the support columns, 3 - the lower platform capable of moving up and down, 4 - an optical sensor that monitors the displacement of the movable sub-platform and the 7, 8 which are working body and the quality of the manufactured element and the displacement of the plastic thread melter tip, 5 - Christavina, 6 - micromotors capable of moving the plastic thread melter attached to the ends of the christavina by 360 degrees in the environment of the operating range of the printer, 7 - plastic thread melter və 8 - tip (both internal working together), 9 - the roll of plastic handle melting by combustion, 10 - automatic control system and manufactured element that control the software of the printer and from other auxiliary parts.

The working principle of a 3D-printer

The principle of operation a 3D-printer is similar to the principle of operation a 3D optical switches [4, 5]. The 3D design of the product printed on a 3D-printer is transferred to the memory of the 10-automatic control system, which provides control over the creation of 3D design software and the produced element. From there, based command enters according to the data package,3 moves to the working body. The working body itself has the ability to move up and down (shown by the arrow in Figure 1) According to the command from 10, the plastic handle from 7,9 melts and moves with the help of 8 on the lower platform according to the design of the required element according to the contours of the element produced by micromotors and pours the molten plastic thread on 3 and as a result, a device is prepared according to the command entered from 10.

All states of the manufactured device or any element are displayed on the LCD screen, instead of the LCD screen, other computer terminals such as a USB port, Bluetooth modules, etc. can be used. Control of all 6micromotors, regulation of the state of movement of 3, 7, 8 are carried out by means of the feedback circuit with the help of part 10 of the device. With the help of sensors in the electronic control and measuring system integrated into the device, it is possible to constantly monitor the operation of the 3D-printer and effectively diagnose its problems.

In accordance with the principle of operation of the 3D-printer and its elements, the control circuit of the 3D-printer is proposed.

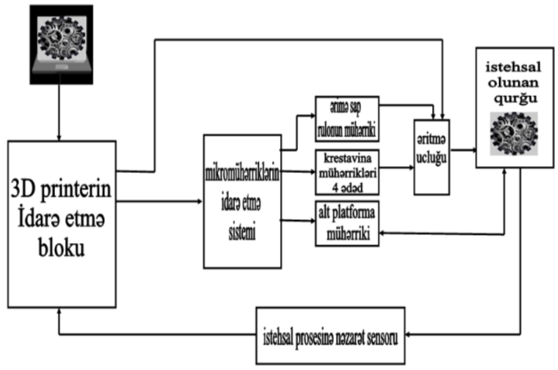

Figure 2 – Control circuit of a new generation 3D printer

Let's look at the principle of operation of the control circuit of the new generation 3D-printer shown in Figure 2 under the following conditions:

1. The control unit of the 3D-printer has 4 states: The input of the control unit receives a signal from the e-system or not.
2. A melt or stop commandis given to control the level of heating, which is sent to the melting point.
3. The three states of the engine control system can be the command to start or stop the engine of the melting thread roll.
4. Operation and stop command of krestavina engines, command given to the engine to move the lower platform up and down, command given to the engines to move the lower platform up and down. There are 2 possible positions of the melt thread motor: start and stop. Other engines have two compatible conditions. The condition of the manufactured device is a complex variable. Taking into account the two states of the production process control sensor, sends a signal to the

control unit with the command "0" at the output if the production of the manufactured element is normal, and "1" if there is an error.

As can be seen, the 3D-printer does not need any other elements to operate in the X, Y and Z axis, and the production accuracy of the printed element is fully controlled as a result of the side effects [3].

Taking into above account, it is important to calculate more efficient management and regulation models and algorithms, including the probability of uninterrupted operation. In this regard, the development of decompositional and multilevel control and mathematical modeling algorithms, the synthesis and study of the optimal control system for acceleration are of particular importance [3]. This approach significantly simplifies the management of the 3D-printer and increases its ability to work in real conditions and productivity.

Let's look at the displacement of the printer's cap under the above conditions. During the transition of the working trajectory $x(t)$ of the working body of the 3D-printer from its initial state to the final state, $x_1(t)$ corresponds to the Euclidean norm [6, 7, 8]

$$F = \|x(t)\| = [x_1^2(t) + x_2^2(t) + \cdots + x_n^2(t)]^{0.5} = (x_T - x)^T (x_T - x),$$

taking into account the task trajectory in accordance with the command from the control unit of the 3D-printer will be. Here, the x -printer status variables depending on t are the final state to which the x_T -system will be brought. Since the scalar quantity F is a positive definite function, its zero means that all x_1 coordinates are equal to zero. Fig. 3 shows the variable nature of the F function.

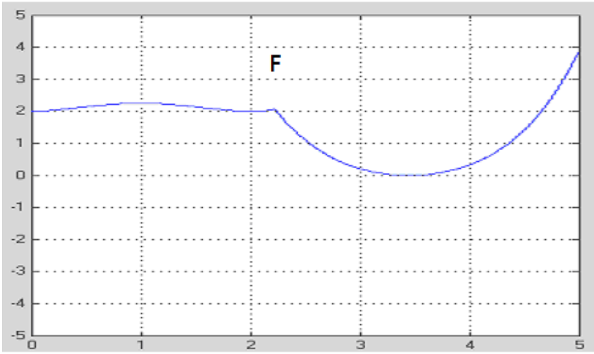

Figure 3 – The changing nature of the F function

In this case reason, it is possible to determine the position of the $x(t)$trajectory relative to the coordinate origin by continuously monitoring F in the system, and based on this, the arrival of the 3D-printer working body at the coordinate origin is detected by controlling the Euclidean norm$F = \|x(t)\|$. When the condition $F = 0$ is satisfied $x(t) = 0$.

Conclusion

As a result of the analysis of the design of 3D-printers, the new design and principle of operation of the 3D-printer was presented, the research and synthesis of the control system of the drivers of the working body of the 3D-printer were considered, and the optimal control problem and printer decomposition control algorithm were developed. Since the equations of motion of the working body of the 3D-printer and all related items consisting of high-level static and dynamic equations, the problem of optimal control is solved on the basis of a linear model by linearization of non-linearity and nonlinearity. At the same time, the construction features of the optimal stabilization system for hardening were studied and a software-controlled stabilization system was established.

REFERENCES

1. RU2649738C12018.04.04. Teplinsky Georgy Georgievich (RU) 3D-Printer *(in Russian)*
2. RU181398U12018.07.12. Novichikhin Pavel Nikolaevich (RU) 3D-Printer *(in Russian)*
3. **Hasanov M.H., Hajiyeva K.R.**, New Generation 3D Printer, Ministry of Education of Azerbaijan Republic, Sumgayit State Unıversity. Conference Proceedings. 2020, № 7. Pp.273-275 *(in Azerbaijani)*
4. **Hasanov M.H.** Photon switch of full optical networks. T-Comm. Vol. 13, №8. 2019. Pp. 47-51. *(in English)*
5. **Hasanov M.H.** 7D optical photon switch of full optical networks // *Herald of the Azerbaijan Engineering Academy*, Baku, 2019, vol. 11, №4. Pp. 65-69 *(in Azerbaijani)*
6. **Rzaev T.G, Farkhadov V.G** Decomposition model of an industrial robot. Materials 46-oy NTK, Scientific notes of AzTU, Baku, Vol. VII, №2, 1998, Pp.7-9 *(in Azerbaijani)*
7. **Fu K., Gonzalez R., Lee K.** Robotics. Moscow: *"World",* 1989, 240 p. *(in English)*
8. **Samedov R.Y., Rustamov Q.A., Namazov M.B., Farhadov V.Q.** Identifier of initial conditions for adjoint variables in minimum time optimal control problem. Proceedings of the international conference on modeling and simulation. The Association for Modelling and Simulation in Enterprises (AMSE) and Selcuk University with the Selcuk University Research Center of Applied Mathematics. August 28-30, Konya, Turkey, vol. II, 2006, Pp.795-798. *(in English)*

Received: 12.09.2021
Revised: 11.12.2021
Accepted: 15.12.2021